RWTH Aachen Physik
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Inst. II B

Master thesis

Scanning Tunneling Spectroscopy of the 2D Topological Insulator Bismuthene

The recent realization of topological superconductivity based on 2D Topological Insulators (2DTIs) raised the possibility to design Majorana zero modes (MZMs), that are predicted to obey non-Abelian exchange statistics as key to fault-tolerant quantum computation. Bismuthene, a monolayer of Bi atoms on top of SiC (0001), arranged in a honeycomb lattice **(Fig. 1),** features non-trivial 2D topology with record-large band gap of 0.8 eV around the Fermi level **(Fig. 2)**. This makes Bismuthene/SiC (0001) a key candidate for combining a 2DTI with a conventional superconductor in order to demonstrate MZMs. Scanning tunneling spectroscopy (STS) is the most direct method to detect the topological edge states of the 2DTI (**Fig. 2**) as well as the MZMs.

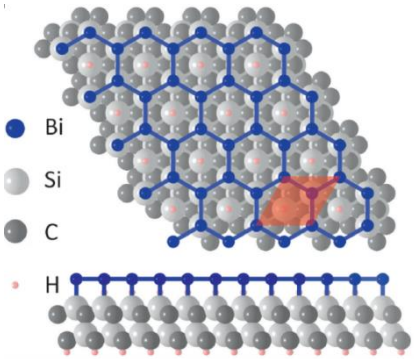

Fig. 1 Sketch of a two dimensional sheet of Bismuthene on a SiC(0001) substrate [1].

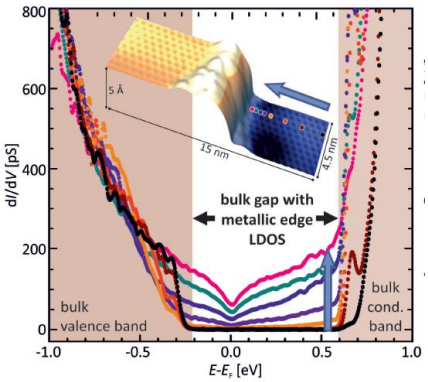

Fig. 2 Tunneling spectroscopy of Bismuthene showing edge states at substrate steps [1].

In this master thesis, your first target is the growth of high quality Bismuthene on SiC (0001) [1]. Afterwards, the Bismuthene will be studied in detail by room temperature STS with a focus on the characterization of the topological edge states. The Bismuthene is grown epitaxially on hydrogenated SiC (0001) [1]. Substrate preparation by hydrogenation and subsequent Bismuthene growth are both performed in an ultrahigh vacuum chamber equipped with a room temperature scanning tunneling microscope (STM) **(Fig. 3)**. The STM is employed to probe the bandgap and the topological edge states. These edge states will then be covered by the s-wave superconductor Nb for studies of MZMs by STM/STS at 300 mK.

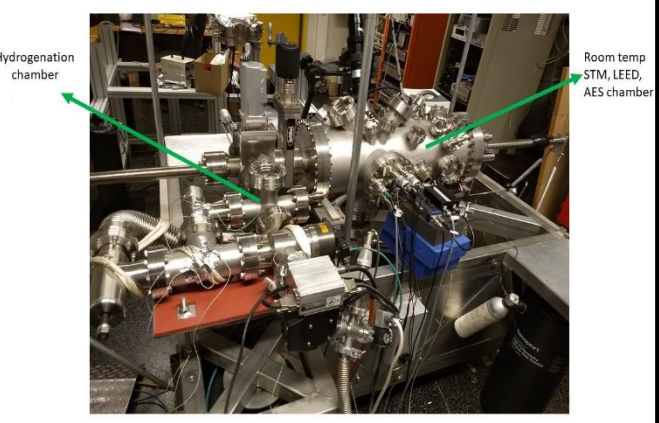

Fig. 3 Ultra High Vacuum Chamber with Room Temperature STM.

You should have a solid background in quantum mechanics and solid state physics, a strong interest in experimental work preferably including technical skills and a dedication to optimize preparation parameters.

References

[1] F. Ries et al., Bismuthene on a SiC substrate: A Candidate for a New High-Temperature Quantum Spin Hall Paradigm, *Science* **357**, 287–290 (2017).

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